

**U.S. FISH AND WILDLIFE SERVICE  
SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM**

SCIENTIFIC NAME: *Partula gibba*

COMMON NAME: Humped tree snail; akaleha

LEAD REGION: Region 1

INFORMATION CURRENT AS OF: April 2010

**STATUS/ACTION**

☐ Species assessment - determined we do not have sufficient information on file to support a proposal to list the species and, therefore, it was not elevated to Candidate status

☐ New candidate

☒ Continuing candidate

☐ Non-petitioned

☒ Petitioned - Date petition received: May 11, 2004

☐ 90-day positive - FR date:

☒ 12-month warranted but precluded - FR date: May 11, 2005

☒ Did the petition request a reclassification of a listed species?

**FOR PETITIONED CANDIDATE SPECIES:**

a. Is listing warranted (if yes, see summary of threats below)? Yes

b. To date, has publication of a proposal to list been precluded by other higher priority listing actions? Yes

c. If the answer to a. and b. is "yes", provide an explanation of why the action is precluded.

Higher priority listing actions, including court-approved settlements, court-ordered and statutory deadlines for petition findings and listing determinations, emergency listing determinations, and responses to litigation, continue to preclude the proposed and final listing rules for the species. We continue to monitor populations and will change its status or implement an emergency listing if necessary. The "Progress on Revising the Lists" section of the current CNOR (<http://endangered.fws.gov/>) provides information on listing actions taken during the last 12 months.

☒ Listing priority change

Former LP: ☐

New LP: ☐

Date when the species first became a Candidate (as currently defined): November 15, 1994

☐ Candidate removal: Former LPN: ☐

☐ A – Taxon is more abundant or widespread than previously believed or not subject to the degree of threats sufficient to warrant issuance of a proposed listing or continuance of candidate status.

- \_\_\_ U – Taxon not subject to the degree of threats sufficient to warrant issuance of a proposed listing or continuance of candidate status due, in part or totally, to conservation efforts that remove or reduce the threats to the species.
- \_\_\_ F – Range is no longer a U.S. territory.
- \_\_\_ I – Insufficient information exists on biological vulnerability and threats to support listing.
- \_\_\_ M – Taxon mistakenly included in past notice of review.
- \_\_\_ N – Taxon does not meet the Act’s definition of “species.”
- \_\_\_ X – Taxon believed to be extinct.

ANIMAL/PLANT GROUP AND FAMILY: Snails; Family Partulidae (snail)

HISTORICAL STATES/TERRITORIES/COUNTRIES OF OCCURRENCE: Guam; Commonwealth of the Northern Mariana Islands (Islands of Rota, Aguiguan (also known as Agujan or Goat Island), Tinian, Saipan, Anatahan, Sarigan, Alamagan, and Pagan).

CURRENT STATES/COUNTIES/TERRITORIES/COUNTRIES OF OCCURRENCE: Guam; Commonwealth of the Northern Mariana Islands (CNMI) (Islands of Rota, Aguiguan, Saipan, Sarigan, Alamagan, and Pagan). Likely extirpated from Tinian and Anatahan.

LAND OWNERSHIP All but 3 of the 14 known populations are on privately owned lands. The other 3 sites are on Federal lands owned by the U.S. National Park Service (American Memorial Park Saipan) and the U.S. Department of Defense (DOD), including one site that is within DOD lands managed by the U.S. Fish and Wildlife Service (Service) as the Guam National Wildlife Refuge (Refuge) and one site on U.S. Navy lands on Guam.

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LEAD FIELD OFFICE CONTACT: Pacific Islands Fish & Wildlife Office, Christa Russell (808) 792-9400, christa\_russell@fws.gov

## BIOLOGICAL INFORMATION

### Species Description

The shell of the humped tree snail (*Partula gibba*) was described by Pilsbry (1909-1910) as “conic-ovate, perforate, rather solid, striatulate, pellucid, engraved longitudinally with equal lines, white or flesh-colored, the spire acute, rose-red, the suture milk-white; epidermis thin and refescent. Whorls 4 ½, the last swollen, gibbous, larger than the rest. Aperture long-ovate, subquad-rangular; peristome reflexed, broadly dilated, white. Var. ruddy-black.”

### Taxonomy

The genus *Partula* has four species found only in the Mariana Islands, and 94 additional species recorded from other Pacific islands (Cowie 1992). The humped tree snail was first collected on Guam in 1819 by Quoy and Gaimard during the Freycinet Uranie expedition of 1817-1819 (Crampton 1925). Crampton’s 1925 taxonomic work is the most recent and accepted taxonomy for this species.

### Habitat/Life History

The humped tree snail prefers cool, shaded forest habitats (Crampton 1925; Cowie 1992; Smith 1995) with high humidity and reduced air movement that might otherwise promote excessive water loss. Crampton (1925) described the habitat requirements of the partulid tree snails of the Mariana Islands as: “a sufficiently high and dense growth to provide shade, to conserve moisture, and to effect the production of a rich humus. Hence the limits to the areas occupied by Partulae are set by the more ultimate ecological conditions which determine the distribution of suitable vegetation.” Crampton (1925) further describes the intact structure of native Mariana forests as having four general levels: the high trees; the shrubs and *Pandanus*; the cycads and taller ferns; and the succulent herbs. He notes that the Mariana Islands partulid tree snails preferentially live on subcanopy vegetation and do not use the high canopy trees. The habitat requirements for the humped tree snail include coastal strand vegetation, forested river borders, and lowland and highland forests (Crampton 1925).

The biology of the partulid tree snails of the Mariana Islands has not been studied in detail. However, general information on the biology of closely related partulid tree snails has been published and reviewed by Cowie (1992) and the biology of all these species is very similar. As with all terrestrial pulmonate (having lungs or lung-like organs) snails, the Mariana Islands tree snails are hermaphroditic. In general, partulid snails begin reproducing in less than 12 months and may live up to 5 years. Up to 18 young are produced each year and some species may be self-fertile. While most terrestrial snails lay eggs, the partulid tree snails give birth to live young. The snails are generally nocturnal, living on bushes or trees and feeding primarily on senescent or decaying plant material. There are no known natural predators of these snails, although many of these species are currently threatened by alien predators (Cowie 1992).

### Historical Range/Distribution

The three genera and 123 tree snail species of the family Partulidae are restricted to the high-elevation Pacific islands of Polynesia (excluding Hawaii), Melanesia, and Micronesia (Cowie 1992; Paulay 1994). The Mariana archipelago historically supported five species of partulid tree snails, and represents the northwestern limit of the geographical range of the Partulidae.

The humped tree snail is the most widely distributed tree snail in the Mariana Islands and was known from Guam, Rota, Aguiguan, Tinian, Saipan, Anatahan, Sarigan, Alamagan, and Pagan. Upon its discovery, this snail was considered to be the most common tree snail on Guam, occupying the branches of trees in cool and shaded habitats (Crampton 1925).

### Current Range/Distribution

Currently there are 14 known populations on 7 islands (Guam, Rota, Aguiguan, Saipan, Sarigan, Alamagan, and Pagan). This species is likely no longer extant on Tinian and, due to volcanic activity from 2003-2005, is possibly extirpated from Anatahan. Historically this species was on Guam and Rota, this species was historically widely distributed and abundant but is currently highly localized and rare.

### Population Estimates/Status

This species is considered to be rare throughout most of its range (Hopper and Smith 1992). The

best estimate for the total number of remaining snails is under 2,600. Details follow regarding the species in various parts of its range.

#### Guam

Crampton (1925) found the humped tree snail at 33 of 39 sites and recorded between 2 and 412 snails at each site; a total of 3,204 individuals were recorded. The actual population sizes were probably considerably larger since the purpose of Crampton's collections was to evaluate geographic differences in shell patterns and not to assess population size. Since the work of Crampton (1925), no significant evaluation of the humped tree snail occurred until the 1980s and 1990s. In 1989, Hopper and Smith (1992) resurveyed 34 of Crampton's 39 sites plus 13 new sites. None of the 34 sites resurveyed by Hopper and Smith (1992) still supported this snail species.

Of the 13 new sites surveyed by Hopper and Smith (1992), 3 sites (Tanguisson Point, Hilaan, and Haputo) were inhabited by the humped tree snail. However the small colony at Tanguisson Point was extirpated by Typhoon Omar in 1992 (B. Smith, University of Guam, pers. comm., 2006). The colony at Hilaan, located within Navy property, is restricted to a small grove of *Merrilliodendron megacarpum* (faniok) trees and has declined from about 100 snails to 20 (B. Smith, pers. comm. 2006). Surveys were conducted in 2008 and no humped tree snails were found at this location (C. Aguon, Guam Division of Aquatic and Wildlife Resources, *in litt.* 2009). The third colony at Haputo, has declined greatly in numbers (C. Aguon, *in litt.* 2009). . Service surveys of 15 sites on the Guam Naval Magazine found no additional populations, while ground shells of tree snails were found in abundance at all locations (S. E. Miller, Service, pers. comm. 2007).

#### Saipan

Crampton (1925) surveyed 8 sites on the island of Saipan, collecting 6,698 humped tree snails. In 1991 Smith and Hopper (1994) could not find any snails at 12 sites visited on the island. Only 2 of Crampton's original 8 sites still had the native vegetation needed to support the tree snails. The shells of dead *Partula* tree snails were found at all the survey sites. In 2002, a small population was identified on the Quitugua property in the village of As Teo (CNMI, Division of Fish and Wildlife (DFW) 2002). In 2004, an additional single small population of the humped tree snail was found in a mangrove wetland at the American Memorial Park on Saipan (National Park Service 2004).

#### Tinian

The island of Tinian has not recently been surveyed. However, the presence and abundance of a predatory flatworm coupled with severe loss of habitat prior to, during, and since World War II, make the continued existence of the humped tree snail on Tinian unlikely (Smith 1995).

#### Rota

The island of Rota was most recently surveyed in April 1996 for *Partula* tree snails (Bauman 1996). Of 25 surveyed sites, only 5 supported populations of the humped tree snail. The largest of these may have had up to 1,000 snails. However, this population was located along the main road of Rota and was subsequently cleared for development (S.E. Miller, pers. comm. 2007) The four other populations are small and total less than 600 snails (Smith 1995).

### Aguiguan

In 1985, 7 adult snails were collected from the west end of the island (Smith 1995). In 1992, snails were observed at three locations on the island (Craig and Chandran 1992). A second survey in 1992 reported two humped tree snails on the northwest terrace of the island (Smith 1995).

### Pagan, Alamagan, Anatahan, Sarigan

The humped tree snail has also been reported from the remote northern islands in surveys done in 1949 and in 1994. These small volcanic islands are difficult to access though agricultural activity occurs on Pagan and Alamagan. The DOD has issued a notice of intent to issue an environmental assessment on planned military activity for all four of these islands (E. Campbell, Service, pers. comm. 2007). The species was first reported in 1949 from 6 locations (28 adult snails plus numerous juveniles, with 17 adults from one location) on the island of Pagan in a thin breadfruit agro-forest and from 5 locations (339 adult snails plus numerous juveniles, with 49 adults at a typical site) on Alamagan in wet forest (Kondo 1970). These observations probably represent a single fragmented population on each of these small islands.

In 1994, Kurozumi reported snails from Anatahan (19 snails from 3 locations, with 14 snails from a single site), Sarigan (102 snails from 7 locations, with 53 snails from a single site), Alamagan (123 snails from 7 sites, with 58 from a single site), and Pagan (22 snails from a single site). As with the Pagan and Alamagan populations, the snails on Anatahan and Sarigan were probably part of two fragmented populations, one on each island. On Anatahan, the population is possibly extirpated due to volcanic eruptions during 2003 to 2005. These eruptions have removed an estimated 95% of all vegetation and the effect on the snails is unknown but presumed to be negative (Service and CNMI DFW 2006).

The humped tree snail continues to survive on Pagan, Alamagan, and Sarigan although since 1949 the species seems to have declined on Pagan and Alamagan by over 70 percent for individuals, and by approximately 27 percent for populations (Kurozumi 1994). On Sarigan the population appears to be increasing as a result of the removal of ungulates. A survey in April of 2006 found the healthiest population in native forest at an elevation of approximately 1,312 feet (400 meters) (B. Smith, pers. comm. 2006). However, native forest is not yet widespread on Sarigan and in mixed forests the snail numbers less than 25 percent of the densities in native forest (B. Smith, pers. comm. 2006).

## THREATS

### A. The present or threatened destruction, modification, or curtailment of its habitat or range.

The humped tree snail prefers cool, shaded forest habitats (Crampton 1925; Cowie 1992; Smith 1995) with high humidity and reduced air movement that might otherwise promote excessive water loss. These forest habitats include coastal strand forest, forested river borders, and both lowland and highland native forests (Crampton 1925). Currently, habitat for this species can still be found within its range in the Mariana Islands. However, it has severely declined or has been degraded due to extensive forest clearing for agriculture and development, introduced weed species, and introduced feral ungulates over the last century.

Following World War II, open agricultural fields and other areas prone to erosion were seeded

with *Leucaena leucocephala* (tangantangan) which grows as a single species stand with no substantial understory. The micro-climate in these areas now occupied by tangantangan is dry, with little accumulation of leaf litter humus, and is particularly unsuitable as partulid tree snail habitat (Hopper and Smith 1992). In addition, native forest cannot reestablish and grow where this alien weed has become established (Hopper and Smith 1992).

Throughout the Mariana Islands, feral ungulates (pigs [*Sus scrofa*], Philippine deer [*Cervus mariannus*], cattle [*Bos taurus*], water buffalo [*Bubalus bubalis*], and goats [*Capra hircus*]) have caused severe damage to native forest vegetation by browsing directly on plants, causing erosion (Marshall *et al.* 1995, Kessler 1997), and retarding forest growth and regeneration (Lemke 1992). This in turn reduces the quantity and quality of forested habitat for the humped tree snail. Currently, populations of feral ungulates are found on the islands of Guam (deer, pigs, and water buffalo), Rota (deer and cattle), Aguiguan (goats), Tinian (cattle), Saipan (deer, pigs, and cattle), Anatahan (pigs and goats), Alamagan (goats, pigs, and cattle), and Pagan (cattle, goats, and pigs). Goats were eradicated from Sarigan in 1998 (Zoology Unlimited LLC 1998) and the humped tree snail has increased in abundance, perhaps in response to their removal.

In addition to human-related habitat alteration, natural events such as typhoons and volcanic activity have also impacted the humped tree snail habitat. The island of Anatahan experienced volcanic eruptions, beginning in 2003 and continuing into the earlier part of 2005. Much of the land area was buried by a thick ash layer. These eruptions removed an estimated 95 percent of all vegetation and the effect on the snails is unknown but presumed to be negative (USFWS and CNMI Division of Fish and Wildlife 2006). Pagan has also experienced volcanic activity as recently as 1993.

Typhoons are a common occurrence in the Mariana Islands. Guam, for example, has been affected by typhoons in 37 of the 50 years between 1954 and 2004 (Naval Pacific Meteorology and Oceanography Center Joint Typhoon Warning Center (JTWC) 2007). During the 1990s Guam experienced 20 typhoons, and supertyphoons (having gusts exceeding 150 miles (mi) (240 kilometers (km)) per hour) occur with regularity (about once every 5 to 10 years). There is some evidence that the frequency of severe storms (estimated gusts exceeding 100 mi (160 km) per hour) is increasing in the Mariana Islands. With reference to Guam, the historical record shows increasing numbers of mild (estimated gusts in the range of 50 to 100 mi (80 to 160 km) per hour) and severe storms over the last three centuries, as well as in just the last decade (JTWC 2007).

These storms have been known to defoliate forested areas and down trees, which can impact tree snail populations. For example, in August 2004, Typhoon Chaba stalled 25 mi (40 km) north of Rota for several hours, downing trees and defoliating large sections of the forested areas, especially on the windward side of the island (JTWC 2007). Vegetation changes associated with this storm have opened up forested areas that were excellent habitat for partulid tree snails. These open forests suffer from changes in microhabitat, such as desiccation, that make the continued survival of snails unlikely. These changes continue to occur today with each successive typhoon (F. Amidon, Service, pers. comm. 2005).

B. Overutilization for commercial, recreational, scientific, or educational purposes.

None known.

C. Disease or predation.

Predation by the alien rosy carnivore snail (*Euglandina rosea*) and the alien Manokwar flatworm (*Platydemus manokwari*) is a serious threat to the survival of all four species of partulid tree snails from the Mariana Islands. The predatory rosy carnivore snail is native to the southeastern United States, and was introduced into the Mariana Islands in 1957 (Eldredge 1988). Since being introduced, this voracious predator of snails has been dispersed by humans throughout the main islands. The rosy carnivore snail was imported to these and other Pacific islands as a biological control agent for another alien snail, the giant African snail (*Achatina fulica*), which is an agricultural pest. Field observations have established that the rosy carnivore snail readily feeds on native Pacific island tree snails, including the Partulids of the Mariana Islands (Tillier and Clarke 1983; Murray *et al.* 1988; Miller 1993) and the Hawaiian achatinellid tree snails (Hadfield *et al.* 1993). A study of the diet of the rosy carnivore snail on the island of Mauritius in the Indian Ocean showed that this alien predator preferred native snails over the targeted alien giant African snail (Griffiths *et al.* 1993). On some or all of these tropical islands, the rosy carnivore snail has expanded its normal terrestrial feeding behavior to include native snails found in arboreal habitats (Murray *et al.* 1988; Hadfield *et al.* 1993; Miller 1993). The rosy carnivore snail has caused the extinction of many populations and species of native snails throughout the Pacific islands (Tillier and Clarke 1983; Murray *et al.* 1988; Hopper and Smith 1992; Hadfield *et al.* 1993; Miller 1993). The rosy carnivore snail represents a significant threat to the survival of native Mariana Islands snails, including the humped tree snail.

Predation on native partulid tree snails by the terrestrial Manokwar flatworm is also a threat to the long-term survival of these snails. This voracious snail predator was introduced into Guam in 1978 and has been spread by humans throughout the main Mariana Islands (Eldredge 1988). It has proven to be an effective biological control agent for the giant African snail, but has also contributed to the decline of native tree snails, in part due to its ability to ascend into trees and bushes that support native snails. Areas with populations of the flatworm usually lack partulid tree snails or have declining numbers of snails (Hopper and Smith 1992).

D. The inadequacy of existing regulatory mechanisms.

Currently, no formal or informal protection is given to the humped tree snail.

E. Other natural or manmade factors affecting its continued existence.

Even if the threats responsible for the decline of this species were controlled, the persistence of existing populations is hampered by the small number of extant populations and the small geographic range of the known populations. These circumstances make the species more vulnerable to extinction due to a variety of natural processes. Small populations are particularly vulnerable to reduced reproductive vigor caused by inbreeding depression, and they may suffer a loss of genetic variability over time due to random genetic drift, resulting in decreased evolutionary potential and ability to cope with environmental change (Lande 1988; Pimm *et al.* 1988; Center for Conservation Biology 1994; Mangel and Tier 1994). Randomly occurring natural events such as typhoons and droughts could eliminate one or more of the 14 remaining populations of the humped tree snail. This is especially true due to several life-history features of this and all other partulid tree snails (Cowie 1992): reproductive rates are low; eggs are not

laid as in most terrestrial snails, but the young are born live; dispersal is very limited with most individuals remaining in the tree or bush into which they were born. All of these traits make these snails very sensitive to any random event that could lead to a reduction or loss of reproductive individuals.

#### CONSERVATION MEASURES PLANNED OR IMPLEMENTED

In 1998, feral goats were successfully removed from the small volcanic island of Sarigan.

A project to survey endemic land snails has been funded under the State Wildlife Grant. Snail surveys will be conducted on Tinian, Rota, Saipan, and Asuncion (S. Igisomar, Director, CNMI Division of Fish and Wildlife, *in litt.* 2008)

#### SUMMARY OF THREATS

Based on our evaluation of habitat degradation and loss by feral ungulates and nonnative invasive weeds, and the effects of predation by the nonnative predatory rosy carnivore snail and predatory flatworm, and vulnerability to randomly occurring natural events, we conclude there is sufficient information to develop a proposed rule for this species due to the degradation of its habitat, the threat of predation by the nonnative predatory rosy carnivore snail and predatory flatworm. In addition, the humped tree snail is vulnerable to randomly occurring natural events such as typhoons and storms. We find that this species is warranted for listing throughout all its range, and, therefore, find that it is unnecessary to analyze whether it is threatened or endangered in a significant portion of its range.

For species that are being removed from candidate status:

\_\_\_ Is the removal based in whole or in part on one or more individual conservation efforts that you determined met the standards in the Policy for Evaluation of Conservation Efforts When Making Listing Decisions (PECE)?

#### RECOMMENDED CONSERVATION MEASURES

- Conduct long-term monitoring surveys for the humped tree snail
- Develop and implement nonnative snail removal and control program
- Develop and implement nonnative flatworm removal and control program
- Conduct feral ungulate removal and control program
- Conduct habitat restoration program



## LISTING PRIORITY

THREAT			
Magnitude	Immediacy	Taxonomy	Priority
<b>High</b>	<b>Imminent</b>	Monotypic genus	1
		<b>Species</b>	<b>2*</b>
	Non-imminent	Subspecies/population	3
		Monotypic genus	4
		Species	5
Moderate to Low	Imminent	Subspecies/population	6
		Monotypic genus	7
		Species	8
	Non-imminent	Subspecies/population	9
		Monotypic genus	10
		Species	11
		Subspecies/population	12

Rationale for listing priority number:

### *Magnitude:*

The threats to the humped tree snail from habitat destruction and alteration by feral ungulates, and invasive nonnative plants, and predation from nonnative predatory snails and flatworms are of high magnitude. These threats occur throughout the range of the humped tree snail. Currently there are no efforts in place to control or eradicate nonnative predatory snails or flatworms, or to stop the loss and degradation of habitat by nonnative animals or plants. On Sarigan, feral ungulates have been successfully removed. The small number of individuals and small number of disparate populations also make this species very susceptible to the negative effects of randomly occurring natural events such as typhoons and storms. These threats occur range-wide.

### *Immediacy of Threats:*

The primary threats to this species from habitat degradation and loss from feral ungulates and nonnative plants and from predatory snails and flatworms are imminent because they are ongoing. The small number of individuals and small number of disparate populations also make this species very susceptible to the negative effects of randomly occurring natural events such as typhoons and storms. These events are considered nonimminent.

Rationale for Change in Listing Priority Number (insert if appropriate)

Yes Have you promptly reviewed all of the information received regarding the species for the purpose of determining whether emergency listing is needed?

Is Emergency Listing Warranted?

No. The species does not appear to be appropriate for emergency listing at this time because the

immediacy of the threats is not so great as to imperil a significant proportion of the taxon within the time frame of the routine listing process. If it becomes apparent that the routine listing process is not sufficient to prevent large losses that may result in this species' extinction, then the emergency rule process for this species will be initiated. We will continue to monitor the status of the humped tree snail as new information becomes available. This review will determine if a change in status is warranted, including the need to make prompt use of emergency listing procedures.

#### DESCRIPTION OF MONITORING

We conducted literature searches for recent articles on this species and contacted, CNMI Division of Fish and Wildlife (DFW) and the Guam Division of Aquatic Wildlife and Resources (DAWR) regarding the current status of this species. New information on the species' status was provided and incorporated into this assessment. Existing data regarding the species' status was verified.

This level of monitoring is appropriate to update the status of the species because a thorough literature search was conducted as well as relevant species experts contacted. Information contained in this assessment form was verified and any updated information incorporated.

#### List of Experts Contacted:

Name	Date	Affiliation
Sylvan O. Igisomar	January 29, 2010	CNMI Division of Fish and Wildlife, Saipan
Celestino Aguon	January 29, 2010	Guam Division of Aquatic Wildlife and Resources

This species is listed as critically endangered (CR) in the International Union for Conservation of Nature and Natural Resources (IUCN) Red Data List database (IUCN 2006). The humped tree snail is included in the list of species in the Guam Comprehensive Wildlife Conservation Strategy (Guam Division of Aquatic Wildlife and Resources 2005) and in the Commonwealth of the Northern Mariana Islands' 2005 Comprehensive Wildlife Conservation Strategy (Berger *et al.* 2005).

#### COORDINATION WITH STATES

On January 29, 2010, we sent a letter to the Guam DAWR and to the CNMI DFW requesting their review and comments on our most recent candidate assessment of this species. No response was received from either CNMI DFW or Guam DAWR.

#### LITERATURE CITED

- Bauman, S. 1996. Diversity and decline of land snails on Rota, Mariana Islands. American Malacological Bulletin, Vol. 12(1/2):13-27.
- Berger, G. M., J. Gourley and G. Schroer. 2005. Comprehensive wildlife conservation strategy for the Commonwealth of the Northern Mariana Islands. Commonwealth of the Northern

- Mariana Islands, Department of Lands and Natural Resources, Division of Fish and Wildlife, Saipan MP. 358pp.
- Center for Conservation Biology. 1994. Nectar, fecundity and conservation planning. Center for Conservation Biology Update, Vol. 8(1): 10 (summer).
- CNMI, Division of Fish and Wildlife. 2002. Population surveys and protection of newly discovered *Partula gibba* population on Saipan. Project proposal. 1pg.
- Cowie, R.H. 1992. Evolution and extinction of Partulidae, endemic Pacific island land snails. Philosophical Trans. Royal Soc. London B 335:167-191.
- Craig, R.J. and R. Chandran. 1992. Wildlife species recorded during the Aguiguan Expedition: 20-25 May, 1992. pp. 1-7. In R.J. Craid (Ed.), The Aguiguan Expedition. Proceedings: Marianas Research Symposium, Northern Marianas College.
- Crampton, H.E. 1925. Studies on the variation, distribution, and evolution of the genus *Partula*. The species of the Mariana Islands, Guam and Saipan. Carnegie Inst. Wash. Publ. 228A. vii + 116pp., 14 pl.
- Eldredge, L.G. 1988. Case studies of the impacts of introduced animal species on renewable resources in the U.S.-affiliated Pacific islands. Pp. 118-146. In B.D. Smith (ed.), Topic reviews in insular resource development and management in the Pacific U.S.- affiliated islands. Univ. Guam Marine Lab. Tech. Rep. 88.
- Griffiths, O., A. Cook, and S.M. Wells. 1993. The diet of the introduced carnivorous snail *Euglandina rosea* and its implications for threatened island gastropod faunas. Journal of Zoology, 229:79-89.
- Guam Division of Aquatic and Wildlife Resources. 2005. Guam comprehensive wildlife conservation strategy (GCWCS). Department of Agriculture, Government of Guam. Mangilao, Guam. 256 pp.
- Hadfield, M.G., S.E. Miller, and A.H. Carwile. 1993. The decimation of endemic Hawaiian tree snails by alien predators. Amer. Zoologist, 33:620-622.
- Hopper, D.R., and B.D. Smith. 1992. The status of tree snails (Gastropoda: Partulidae) on Guam, with a resurvey of sites studied by H. E. Crampton in 1920. Pacific Sci. 46:77-85.
- IUCN 2006. 2006 IUCN Red List of Threatened Species. [www.iucnredlist.org](http://www.iucnredlist.org). Downloaded on 09 March 2007.

- Kessler, C. 1997. Feral animal monitoring and management. *In*: Annual Progress Report, Fiscal Year 1996. Pittman-Robertson Federal Aid in Wildlife Restoration Program. Division of Fish and Wildlife, Commonwealth of the Northern Mariana Islands, pp. 8-14.
- Kondo, Y. 1970. Some aspects of Mariana Islands Partulidae (Mollusca, Pulmonata). *Occas. Pap. B.P. Bishop Mus.* 24(5):73-90.
- Kurozumi, T. 1994. Land molluscs from the northern Mariana Islands, Micronesica. *Nat. Hist. Res., Spec. Iss.* 1:113-119.
- Lande, R. 1988. Demographic models of the northern spotted owl (*Strix occidentalis caurina*). *Oecologia* 75: 601-607.
- Lemke, T.O. 1992. Status of the Marianas fruit bat (*Pteropus mariannus*) in the Northern Mariana Islands north of Saipan. *In*: Wilson, D.E. and G.L. Graham (eds.), Pacific Island Flying Foxes: Proceedings of an International Conservation Conference. U.S. Fish and Wildlife Service Biological Report 90(23):68-73.
- Mangel, M. and C. Tier. 1994. Four facts every conservation biologist should know about persistence. *Ecology* 75: 607-614.
- Marshall, A.P., D.J. Worthington, G.J. Wiles, D.J. Grout, C.C. Kessler, V.A. Camacho, E.M. Taisacan, and T. Rubenstein. 1995. A survey of the Mariana fruit bat (*Pteropus mariannus*) on Anatahan, CNMI, July 1995. Division of Fish and Wildlife, CNMI. Unpublished report. 28pp.
- Miller, S.E. 1993. Final report on surveys of the arboreal and terrestrial snail fauna of American Samoa. Unpublished report submitted to U.S. Fish and Wildlife Service, Pacific Region, Honolulu. 30 pp.
- Murray, J., E. Murray, M.S. Johnson, and B. Clarke. 1988. The extinction of *Partula* on Moorea. *Pacific Sci.* 42:150-153.
- National Park Service, American Memorial Park. 2004. Letter to USFWS, PIFWO regarding the re-discovery of *Partula gibba* within the American Memorial Park on Saipan.
- Naval Pacific Meteorology and Oceanography Center Joint Typhoon Warning Center. Annual tropical cyclone reports. [https://metocph.nmci.navy.mil/jtwc/atcr/atcr\\_archive.html](https://metocph.nmci.navy.mil/jtwc/atcr/atcr_archive.html). Downloaded on March 29, 2007.
- Paulay, G. 1994. Biodiversity on oceanic islands: Its origin and extinction. *Am. Zoologist* 34:134-144.
- Pilsbry, H.A. 1909-1910. Family Partulidae. *In*: *Manual of Conchology*, 2<sup>nd</sup> ser., 20:155-336.

- Pimm, S., H. Lee Jones, and Jared Diamond. 1988. On the risk of extinction. *American Naturalist* 132: 757-785.
- Smith, B.D. 1995. Tree snails, tropical storms, and drought in the Mariana Islands. (Abstract only). Programs and abstracts, American Malacological Union, 61st Annual Meeting, Hilo, Hawaii.
- Smith, B.D., and D.R. Hopper. 1994. The Partulidae of the Mariana Islands: Continued threats and declines. *Hawaiian Shell News* 42(6):10-11.
- Tillier, S. and B.C. Clarke. 1983. Lutte biologique et destruction du patrimoine genetique: le cas du mollusques gasteropodes pulmones dans les territoires Francais du Pacifique. *Sel. Evol.*, 15:559-566.
- U.S. Fish and Wildlife Service and CNMI Division of Fish and Wildlife. 2006. Anatahan feral ungulate eradication project for Micronesian megapode habitat improvement for the years 2005 and 2006
- Zoology Unlimited LLC. 1998. Report on the eradication of feral ungulates from Sarigan Island, Commonwealth of the Northern Mariana Islands, USA. For U.S. Fish and Wildlife Service, Pacific Islands Ecoregion, Honolulu, HI. Unpublished. 28pp.
- Personal Communications
- Aguon, C., Guam Division of Aquatic and Wildlife Resources, Letter regarding DAWR's response to request for information on candidate assessment forms. March 20, 2009.
- Amidon, F., Service. Memo to file, biologists discussion of conditions on Rota. July 11, 1995.
- Campbell, E., Service. Notes to file in response to email question about agriculture and military activity on Pagan, Alamagan, Anatahan, and Sarigan.
- Igisomar, S.O. CNMI Division of Fish and Wildlife, Letter regarding CNMI's response to request for information on candidate assessment forms. February 27, 2008.
- Miller, S. E., Service. Notes to the file in response to a request to summarize Mariana Islands, Guam, and American Samoa snail information. March 13, 2007.
- Smith, B., University of Guam. Email in response to request for review of candidate assessment forms. September 14, 2006.

APPROVAL/CONCURRENCE: Lead Regions must obtain written concurrence from all other Regions within the range of the species before recommending changes, including elevations or removals from candidate status and listing priority changes; the Regional Director must approve all such recommendations. The Director must concur on all resubmitted 12-month petition findings, additions or removal of species from candidate status, and listing priority changes.

Approve:

Acting Carolyn D. Bohan 5/18/10  
Regional Director, Region 1, Fish and Wildlife Service Date

Ronan W. Gould  
ACTING  
Director, Fish and Wildlife Service October 22, 2010

Concur:

Do not concur: \_\_\_\_\_  
Director, Fish and Wildlife Service Date

Director's Remarks:

Date of annual review: April 16, 2010  
Conducted by: Lorena Wada, Pacific Islands FWO  
Biologist, Prelisting and Listing Program

Comments:  
PIFWO Review

Reviewed by: Christa Russell Date: April 23, 2010  
Prelisting and Listing Program Coordinator

Marilet Zablan Date: April 26, 2010  
Assistant Field Supervisor, Endangered Species Division

Gina Shultz Date: April 30, 2010  
Acting Field Supervisor